

# Biopathways to Carbon Neutrality – LONG VERSION

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## 1 Introduction

The Natural Resources Institute Finland (Luke) was commissioned by the Ministry of Agriculture and Forestry to review central EU-level documents concerning the bioeconomy focusing on carbon and climate issues, as well as to consider the documents' hierarchy and possible contradictions, and to present the results in a concise brief. The work was carried out in November-December 2017. Other reviews were used to support the work, particularly Ronzon et al. (2017) [1], Hetemäki et al. (2017) [2], Review of the 2012 European Bioeconomy Strategy (2017) [3] and Hytönen (2017) [4].

## 2 EU Bioeconomy Strategy

The EU Bioeconomy Strategy and Action Plan (EC 2012) [5] was published to focus European efforts on the bioeconomy. It is related to international commitments such as the climate agreements and the United Nations Millennium Development Goals (which were replaced by the UN Sustainable Development Goals (SDG) in 2016). The Strategy supports four Flagship initiatives of the Europe 2020 strategy (innovation, resource-efficiency, industrial policy, new skills and jobs) as well as four priorities of the Juncker Commission. The Strategy focuses on investments in research, innovation and skills; re-enforcement of policy interaction and stakeholder engagement; and enhancement of markets and competitiveness in the bioeconomy sectors. The sectors are those supplying biomass (agriculture, forestry, fisheries/aquaculture/algae, as well as bio-based waste from all sectors) as well as those using biomass (food, energy, and bio-based industries). Services, both nonmaterial ones like recreation and the ecosystem services like pollination, are mentioned only in passing. Several Member States (MS), including Finland, have later drafted their own Bioeconomy Strategies and related policies.

The Strategy uses the term low-carbon society and makes several references to the need to reduce greenhouse gas (GHG) emissions. The EU pulp and paper, chemical and food industries are seen as sources of GHG, but are also noted to store important amounts of carbon in their products. Promoting the substitution of carbon, energy and water intensive production processes by more resource efficient and environmentally friendly ones is a task of the Strategy. The partial replacement of non-renewable products by more sustainable bio-based ones is encouraged. There are also a few mentions – particularly in the accompanying Commission **Staff Working Document** [6] – of enhancing sequestration of carbon in agricultural and forest soils as well as sea beds.

Various EU bodies and stakeholders have recently expressed their views about the Bioeconomy Strategy; these are discussed in the end of this analysis.

## 3 Other Relevant EU Strategies and Policies

### 3.1 EU climate policy 2020-2030

EU climate policy is underpinned by the Paris Agreement. The agreement is legally binding, but its parties may decide their own Nationally Determined Contribution (NDC). The EU, as a single entity, has committed to jointly reducing its emissions by 40% from 1990 levels by 2030.

The EU is laying down its climate policy for the years 2020-2030, affecting the future bioeconomy operating environment, although the term “bioeconomy” is not mentioned in the documents reviewed here. Three components of the legislation are especially of interest: (1) the **Effort Sharing**

**Regulation (ESR)** [7-9], (2) the **Land Use, Land Use Change and Forestry Regulation (LULUCF)** [10], and (3) the **Renewable Energy Directive** [11-13]. All three are still in the making, and the analysis is based on versions (proposals) that were available at the time of writing in Nov. 2017.

The EU Emissions Trading System (ETS) covers most emissions from power and heat generation, energy-intensive industries and commercial aviation. The ESR covers emissions from energy, industrial processes, product use, agriculture and wastes that are not regulated by the ETS (e.g. transport and construction). The LULUCF regulation covers emissions from land use and forestry (except for those parts of agriculture that are covered by the ESR).

Emissions in the ETS sector are to be reduced by 43% by 2030 compared to the 2005 level. The reductions are obtained by reducing the amount of tradable permits in the market and are not specific to each MS. The respective EU-level reduction target for the ESR sector (a.k.a. ESD sector, D=Decision) is 30% [7]. This target is divided into separate reductions targets for countries, ranging from -0% to -40% [8]. Finland's target is -39%. The LULUCF Sector has a "no-debit" rule (Article 4, [10]), which means that emissions may not exceed removals in the sector in any MS. However, the accounting rules for emissions and removals (Articles 5-10 [10]) do not directly adhere to absolute flux measurements.

The EU has numerous other policy initiatives that interact with the sectoral policies. These initiatives do not directly affect total GHG emission targets but they partly determine the means by which the targets are to be reached. For example, the renewable energy directive sets the objective of increasing the share of renewables to 27% of total EU energy consumption by 2030 (30% has also been proposed) [11, 13]. Thus, while reducing emissions to meet the targets outlined by ESR and LULUCF regulation, countries also need to make sure that the consumption share of renewable energy is increased. The renewable energy target is viewed as an objective in its own right.

### **Effort Sharing Regulation**

The ESR [7-9] determines the Member States' minimum emission reduction obligations and lays down the rules for determining annual emission allocations and evaluating progress. Each MS must ensure that its annual emissions do not exceed its allocations. However, there are flexibilities that allow transferring allocated quotas: temporal flexibilities between years, sectoral between the ETS, ESR and LULUCF sectors, and flexibilities between Member States (see Fig.1).

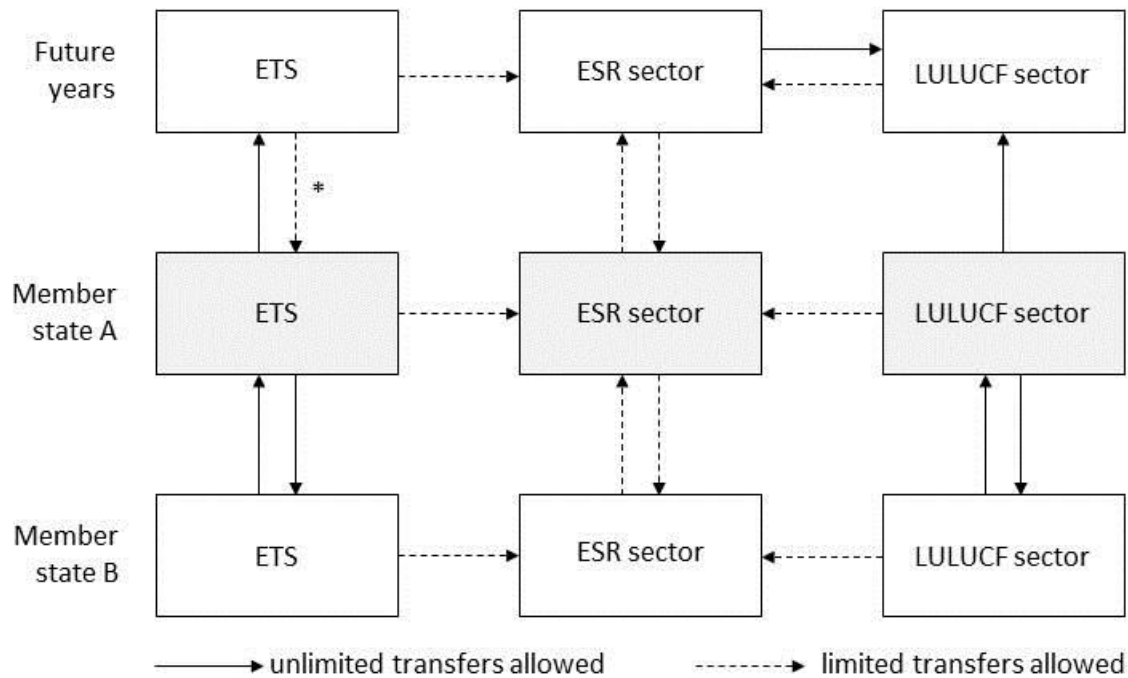
### **LULUCF Regulation**

The LULUCF Regulation [10] lays down the Member States' minimum emission reduction obligations for the LULUCF sector, the accounting rules and the rules for checking Member States' compliance with their commitments.

Net carbon stock changes in cropland, grassland, forests and harvested wood products are accounted (Articles 2 and 5-10 [10]), and a MS may also voluntarily opt to include wetlands and settlements (Article 2 [10]). The additionality principle is applied in the accounting: carbon stock changes during the commitment period are compared to a predefined reference level and only net emissions (or removals) exceeding the reference level are accounted (Articles 7-8 [10]). Net emissions from each land use class are accounted separately, and then summed to obtain total LULUCF emissions.

The accounting practices for forests differ from those for other land use categories. Positive net emissions (exceeding the reference level) are fully accounted. However, negative net emissions (i.e.

net removals) are only credited up to a national cap (Article 8 [10]). Net removals resulting from storing carbon in harvested wood products are not subject to this limitation (Article 8 [10]).



**Figure 1:** Permitted allowance transfers between sectors, countries and years in EU climate policy, as outlined in sources [7-10]. Member state A represents any given EU country. Member state B represents other EU countries. (See footnote for explanation of \*).

The legislation drafts include the following transfer rules: ETS allowances may be freely traded across national borders. Allowances may also be banked without restriction, but they cannot be (officially) borrowed from future years<sup>1</sup>. Quota transfers between countries in the ESR sector are restricted. Likewise, the banking and borrowing of allowances is restricted. Within the LULUCF sector, transfers between countries are not limited. Banking is allowed, but borrowing is not. Subject to certain restrictions, allowances from the ETS and reductions in the LULUCF sector may be used to compensate emissions in the ESR sector. However, ESR sector allowances may not be transferred to the ETS sector. If LULUCF sector emissions exceed removals, the excess emissions will be deducted from the ESR sector allocation.

### Renewable Energy Directive

This review covers the proposal for the new renewable energy directive [11, 13]. The share of renewables is to be raised to 27% of total EU energy consumption by 2030. The directive sets binding national targets (Finland having 50%) and establishes sustainability and GHG emissions saving criteria for biofuels, bioliquids and biomass fuels. The scope of the directive is broad. Here we focus on two issues of particular interest from the vantage point of the bioeconomy: (1) transport biofuels, and (2) the sustainability criteria for biofuels, bioliquids and biomass fuels.

<sup>1</sup> \*However, when MS turn in the acquired allowances for the previous year's emissions, they may compensate for excess emissions by purchasing the ongoing year's allowances.

A 12% renewable energy target is set for all forms of transport in all MS (Article 3 [13]). The contribution of biofuels made of food or feed crops may be no more than 7% of final consumption of energy in road and rail transport in each MS. By 2030 this limit is reduced to 3.8% (Article 7, [11,13]).

Fuel suppliers in all MS are required to include a minimum share (at least 1.5% in 2021 and 6.8% in 2030) of advanced biofuels in the total amount of transport fuels they supply (Article 25, [11,13]). Advanced biofuels should be made of wastes and residues (i.e. not food crops, feed crops, logs or pulpwood). The allowable feedstocks from forestry and forest industries include: tall oil, bark, branches, biomass from pre-commercial thinnings, leaves, needles, tree tops, saw dust, cutter shavings, black liquor, brown liquor, fibre sludge, and lignin (Annex IX [12]). From agriculture acceptable feedstocks include manure, straw, certain other residues and e.g., cover crops before and after main crops. The GHG emission savings from the use of advanced biofuels must be at least 70% from installations starting operation after 1.1.2021 (60% from installations that have started 5.10.2015-31.12.2020, 50% from installations that have started operation earlier) (Article 25, [11,13]).

Biofuels, bioliquids and biomass fuels (hereafter “fuels”) must fulfil the sustainability criteria in order to (1) contribute towards the renewable energy targets set for MS, (2) comply with other renewable energy obligations, such as those set for heating and cooling, and transport, and (3) be eligible for financial support under renewable energy schemes. Fuels that do not fulfil the criteria are permissible, but are not considered renewable (i.e. there is no ban on the use of any feedstock).

To fulfil the sustainability criteria, fuels must not to be made from biomass obtained from highly biodiverse areas (Article 26, Paragraph 2 [11]). Fuels must not be produced of agricultural biomass obtained from wetlands or forests that have been converted to agricultural land after 1.1.2008. If fuels are produced from forest biomass, (1) the feedstocks must be legally harvested, (2) harvested areas must be regenerated, (3) harvests must not exceed the forests’ long-term production capacity, (4) impacts on soils and biodiversity must be minimized, and (5) areas of high conservation value (such as wetlands and peatlands) must be protected [11]. Member States may place additional sustainability requirements for biomass fuels (Article 26, Paragraph 10 [11]) but not for biofuels and bioliquids (Article 26 Paragraphs 9 [11]).

Biomethane transport use is indirectly supported by the **EU Directive on the deployment of alternative fuels infrastructure** [14] which requires there to be sufficient fuelling points offering pressurized gas (CNG). Since the fuelling stations can offer natural gas alone, the impact on biomethane supply is not guaranteed.

### 3.2 EU Biodiversity Strategy

The Biodiversity Strategy (2011) [15] does not mention the term bioeconomy but emphasises the importance of biodiversity for what can be classified as bioeconomy: “Biodiversity — the extraordinary variety of ecosystems, species and genes that surround us — is our life insurance, giving us food, fresh water and clean air, shelter and medicine, mitigating natural disasters, pests and diseases and contributes to regulating the climate. Biodiversity is also our natural capital, delivering ecosystem services that underpin our economy.” (p. 1) Protecting biodiversity is seen as a way to speed up the transition to a resource efficient and green economy. It is seen as an integral part of the Europe 2020 Strategy and in particular the **resource efficient Europe flagship initiative** [16]. Although protecting biodiversity has costs, biodiversity loss is particularly costly for the economic sectors that depend on ecosystem services (e.g., agriculture and forestry).

Carbon sequestration is not in the focus of the Biodiversity Strategy, but it is mentioned. Biodiversity is noted to contribute to climate mitigation and adaptation. In particular, it is stated that the importance of soil biodiversity in delivering ecosystem services such as carbon sequestration is not yet sufficiently understood.

The current consumption patterns are noted to be unsustainable in the EU, but this is discussed only when considering the impact EU has on biodiversity outside of its borders through imports. The Strategy gives six targets and suggests 20 actions to reach them.

Key policies protecting biodiversity are the **Birds Directive** [17] and **Habitat Directive** [18]. In a 2016 Fitness check they were found to be valid, but as their implementation has been inadequate, an Action plan is underway to improve the implementation and the Directives coherence with broader socio-economic objectives. The Natura2000 network of protected areas covers 18% of land in Europe, restricting some uses of each site.

### European Parliament resolution

European Parliament resolution on the mid-term review of the EU's Biodiversity Strategy [19] has more direct mentions of climate issues than the original Strategy. It does not mention "bioeconomy" but mentions e.g., "green economy" and "circular economy". The Parliament emphasises that protecting biodiversity is an investment that brings great economic benefits and that its protection cannot rely on public funding alone. More than the original Strategy, the review brings up the need to upkeep carbon sinks and to combine biodiversity protection with climate change adaptation and mitigation. It emphasises that biodiversity should be included better in sectoral policies and sustainability criteria should be developed for all biomass use. The review also warns about declining biodiversity as a result of e.g., energy use of agricultural and forest biomasses in both EU and particularly outside of the Union (due to imports to EU). The review also discusses ocean pollution as a result of plastic waste leakage.

### 3.3 Circular Economy

The European Commission adopted a Circular Economy Action Plan [20] in 2015 to stimulate Europe's transition towards a circular economy for global competitiveness, sustainable economic growth and new jobs. Priority areas described in the Action Plan are plastics, food waste, critical raw materials from electronic devices, construction and demolition, and biomass and bio-based products. The bioeconomy is specifically discussed as being significant in providing alternatives to fossil-based products and energy. Biorefineries, capable of processing biomass and bio-waste for different end-uses, are considered important in realising the potential of new materials, chemicals and processes. Circular economy is considered essential in the EU's effort to develop a sustainable, low carbon economy, and has therefore strong synergies with EU's climate objectives.

The legislative proposals focus on waste and include targets and concrete measures for reduction of waste and landfilling, and improved waste management and recycling. The most significant in terms of the bioeconomy and carbon neutrality are briefly described below.

**Waste framework directive proposal** [21] includes recycling targets, landfill reduction target, and measures to promote industrial symbioses. Regarding the bioeconomy, directions on the collection of biowastes and the reduction of food waste are given. The reduction of GHG emissions is

mentioned as a reason for renewing the Directive, but otherwise climate, carbon or the bioeconomy are not mentioned.

A new **proposal for regulating organic fertilisers** [22] has the aim of easing the access of organic and waste-based fertilisers to the EU market, thereby increasing their production and markets. Safety, quality and labelling requirements are included, but the intention is to simplify and reduce the administrative burden for producers seeking access to more than one country.

EC **communication on the role of waste-to-energy in the circular economy** [23] emphasises the waste hierarchy which favours waste prevention, re-use and recycling over energy recovery from waste. According to the Commission, “only by respecting the waste hierarchy [...] waste-to-energy can maximise the circular economy’s contribution to decarbonisation, in line with the Energy Union Strategy and the Paris agreement” (p.10). Anaerobic digestion of organic waste which results in biogas production and digestate that can be used as a fertiliser is classified in the Communication as recycling rather than energy recovery. The Communication does not mention the bioeconomy. It refers repeatedly to the need to reduce GHG emissions from energy production, transport, and waste management.

**The packaging and packaging waste directive** [24] aims at providing a high level of environmental protection and ensuring the functioning of the internal market by avoiding obstacles to trade and distortion and restriction of competition. Reducing waste is the priority objective in the directive. Latest revision in 2015 aimed at reduced consumption of lightweight plastic bags. Transition towards carbon-neutrality through substituting fossil-based packaging materials with renewable and degradable bio-based alternatives is not yet in the directive.

**European Strategy for Plastics in a Circular Economy DRAFT** (no date available) notes that plastics production and the incineration of plastic waste give rise to approximately 400 million tonnes CO<sub>2</sub> per year (2012). Plastics dependence on virgin fossil fuel may create problems of security of supply and of CO<sub>2</sub> footprint. Central issues in the draft Strategy are collecting and recycling plastic, microplastics and the protection of seas from it. The plastics solution is portrayed as a common project which requires co-operation between different parties – petrochemical industry, designers, brands, retailers, recyclers, national and regional authorities, cities and individual citizens – as well as global attention, innovation and investments. Recycling is seen as an important field of employment, and new technologies as potential export articles from the EU, but non-sustainable export of low-quality recycled plastics is considered a problem. There is not much on bio-based feedstocks, but they are noted to be an important area of development. Particular care must be taken to ensure that they result in genuine environmental benefits, given in particular the possible land use impacts. Biodegradable plastics are noted not to always degrade very well. On the other hand, biodegradable plastics are a challenge in recycling.

A **cascading** use of renewable resources, with several reuse and recycling cycles, is encouraged in the circular economy documents. This follows the EU waste hierarchy, and references are made particularly to wood-based materials. For example, a **New EU Forest Strategy** [25] states that “Under the cascade principle, wood is used in the following order of priorities: wood-based products, extending their service life, re-use, recycling, bio-energy and disposal.” (p. 6) In the Bioeconomy Policy Day, organized by the European Commission in Brussels 16 Nov. 2017, following the cascade

principle was considered important, but EU level regulation on it was considered inappropriate by several speakers.

### 3.4 EU Industrial Policy

EU Industrial policy aims to stimulate growth and competitiveness in the manufacturing sector and the EU economy as a whole. The industrial policy has several sector-specific action plans and legislation that supports a wide variety of industrial sectors (e.g. chemicals, textiles, raw materials, forest-based industries). Some bio-based industries such as furniture have no separate, specific policies apart from the Bioeconomy Strategy. Lately, calls have been made to reform some pieces of legislation to better promote the bioeconomy, examples of which are given below. Further analyses are needed to examine thoroughly how the EU industrial policy affects the transition to carbon neutral society and if there are major contradicting impacts.

**Ecodesign directive** [26] is a framework directive that directs the setting of requirements which energy-related products need to fulfil in order to be placed on the market and/or put into service. It aims to increase energy efficiency and the level of environmental protection as well as to increase energy supply security. Current **Ecodesign Working Plan 2016-2019** [27] notes that the directive contributes to the Energy Union and the 2030 energy efficiency target, climate goals and circular economy. It is stated that more systematic tackling of material efficiency (durability, recyclability) should be included, as so far the focus has been on energy savings. Bioeconomy is not mentioned in either Directive or Working Plan specifically. However, there are some product specific regulations [28, 29] that relate to the use of solid fuels such as wood and regulate the energy efficiency and emission levels, as well as information requirements.

There is a range of policies at the EU and Member State level to enhance the sustainability and resource efficiency aspects of the building sector. These could directly or indirectly support the use of less environmentally burdensome materials, such as wood, in construction. According to [2], the **Construction Directive** [30] does not address these needs.

EU **Ecolabel** covers several bioeconomy products, such as textiles and different types of paper. The criteria are updated about every four years, so that the most environmentally friendly 10-20% of the products on the market can meet them. The labelling system is meant to decrease the main environmental impacts over the entire life cycle of the product, and to guide consumption. Recently new EU Ecolabel criteria were published for furniture [31] and wood-, cork- and bamboo-based floor coverings [32]. Food and feed products were recently not considered feasible for Ecolabelling by the European Union Ecolabelling Board (EUEB). New labels based on product's durability, eco-design, upgradeability and reparability may emerge, as longer lifetime for products has been called for [33].

The EU support programmes (e.g. COSME, the programme for the competitiveness of enterprises and SME's) help to achieve the goals of industrial policy. New instruments like the European Fund for Strategic Investments (EFSI), which combines an EU budget guarantee and EIB resources, have been developed. EFSI has already provided investment support for e.g., a bio-product mill of Metsä Fibre Oy. The Council has proposed that at least 40% of the EFSI funds allocated to the areas infrastructure and innovation be contributed to climate action; and that agriculture, forestry, and other sectors of the bioeconomy need to be among those funded [34]. Final decisions have not been made.



### 3.5 EU Cohesion/Regional policy

Regional policy is the EU's main investment policy. Regional Policy targets all regions and cities in the European Union in order to support job creation, business competitiveness, economic growth, and sustainable development, and to improve citizens' quality of life. Regional Policy is delivered through three main funds: the European Regional Development Fund (ERDF, 43%), the Cohesion Fund (CF, 13%) and the European Social Fund (ESF, 18%). Together with the European Agricultural Fund for Rural Development (EAFRD, 21%) and the European Maritime and Fisheries Fund (EMFF, 1%), they make up the European Structural and Investment Funds (ESIF, EUR 450 billion for 2014-2020) ([http://ec.europa.eu/regional\\_policy/en/policy/what/investment-policy/](http://ec.europa.eu/regional_policy/en/policy/what/investment-policy/), 28.11.2017).

Regional Policy investments help to deliver many EU policy objectives and complement EU policies such as those dealing with energy, the environment, research and innovation. A systematic review of these funding mechanisms was beyond the scope of this paper, but the carbon neutral circular bioeconomy can be – and sometimes is – encouraged through them.

A key initiative to take advantage of regional strengths is the Smart specialisation approach that aims to boost growth and jobs by enabling each region to identify and develop its own competitive advantages. Through a bottom-up approach, it brings together local actors for the implementation of long term strategies supported by EU funds.

### 3.6 EU Agricultural Policy

Although forests are a special strength of Finland in terms of the bioeconomy, agriculture and food industry form the largest part of the bioeconomy in Europe [1], and most bioenergy increases are expected to result from agro-biomasses [35]. Agriculture is both an emitter and a sink of greenhouse gases, and agricultural soils contain a large stock of carbon in organic matter. Agriculture can also play a role as a supplier of fossil-replacing biomass and biofuels. The emissions from energy use in agriculture are regulated through the ETS, and those resulting from land use changes in the LULUCF regulation. Dedicated agricultural policy, particularly in the form of the **Common Agricultural Policy (CAP)** has had a minor role.

Emissions from agriculture contribute 10% to EU-28 total GHG emissions. Most of them are from organic and mineral nitrogen fertilisers in the soil (N<sub>2</sub>O), digestion of ruminant livestock (CH<sub>4</sub>), and manure handling (both). The agriculture sector obligations to reduce GHG emission are allocated in the ESR [7-9]. Agricultural emissions in the EU have fallen since 1990 but have recently flat-lined. The reductions were mainly caused by declining livestock numbers, and by reductions in fertiliser use, driven mainly by the **Nitrates Directive** [36] and **Water Framework Directive** [37].

The current CAP measures which are relevant to GHG emissions fall into two groups: decisions about the maintenance of permanent grassland, and decisions about which options to allow as ecological focus areas (EFAs). The first are intended as a means of ensuring that carbon stored in soils is not released by ploughing. The latter may include management or features that act as carbon sinks (such as hedges or wooded strips, agro-forestry, land lying fallow), measures to reduce soil erosion, and measures which may reduce the emissions associated with fertiliser use (N-fixing crops and catch crops/green cover). The funding and the way it is used seem insufficient to address the climate needs [38].

Recent EC Communication on the future of the CAP [39] argues that the CAP must reflect a higher level of climate ambition. There are references to climate and the need to reduce agricultural emissions scattered throughout the document, but concrete policy measures are still missing. There are also specific references to the bioeconomy: particularly as a sustainable business model, combined with circular economy, the bioeconomy should become a priority for CAP plans. By-products from agri-food and forestry sectors are noted, as well as services like ecotourism, all of which are seen as means for growth and jobs in rural areas. The term circular bio-economy is used.

The key idea of the document is to move away from top-down and one-size-fits-all approaches, and to provide increased flexibility to MS on how to implement the CAP. The Union would only set basic policy parameters while MS would have more responsibility as to how to achieve the EU objectives. The proposed model resembles the governance model for the Energy and Climate Framework.

### 3.7 EU Forest Policy

The EU does not have a common Forest Policy, although forest issues have been addressed in the fields of biodiversity, rural development, industry and climate. The 2013 Forest Strategy [25] aims at establishing a framework for forest-related actions in support of sustainable forest management. **Rural Development Regulation** [40] will provide EU-level funding.

Climate issues are discussed from several perspectives. First, forests are noted to be vulnerable to climate change and maintaining and enhancing their resilience and adaptive capacity is emphasised. At the same time, mitigating climate change through the forests' role as sinks and the provision of bio-materials that can act as temporary carbon stores is noted, as well as their use as substitutes that replace fossil-based materials and fuels.

According to the Strategy, advanced wood-based materials and chemicals are expected to play a major role in the EU bioeconomy. However, the Strategy also specifically notes that forests have multiple uses and that the multifunctional role of forests in delivering goods and services, including ecosystem services, needs to be ensured. The **Staff Working Document** accompanying the Strategy [41] also emphasises the cascade principle, but notes that the use of wood for bio-energy may sometimes be the practical first or only option. In addition, as part of a mix of outputs from wood-working plants, e.g., pellets or bioenergy in the form of heat or electricity from wood residues may be sensible.

### 3.8 EU Framework Programme for Research and Innovation

The current EU framework program for research and innovation, Horizon 2020, has three pillars: excellent science, industrial leadership, and societal challenges. Themes dealing with different aspects of carbon neutrality are included especially in societal challenges SC 2 Food security, sustainable agriculture and forestry, marine, maritime and inland water research and the bioeconomy; SC 3 Secure, clean and efficient energy; SC 4 Smart, green and integrated transport; SC 5 Climate action, environment, resource efficiency and raw materials. Horizon 2020 total expenditure is some 74.8 billion euros, of which approximately 5.6% has been estimated to be directly allocated to the bioeconomy [1].

The EU also engages in public-private-partnerships of which an important example is BBU JU (Bio-Based Industries Joint Undertaking), jointly implemented by the EU and the Bio-based Industries

Consortium (BIC). The EU contribution from Horizon 2020 is 975 million euros, and BIC contribution 2.7 billion euros.

In the next framework program (FP9) the Commission aims to take the societal challenges to a next level with a mission approach (see below “LAB – FAB – APP”). The Commission has not yet defined the missions and is gathering suggestions. The transition to a carbon-neutral circular bioeconomy would benefit from an ambitious and concrete mission in the FP9.

#### **LAB – FAB – APP — Investing in the European future we want**

An independent High Level Group was asked to draw up a vision and strategic recommendations to maximise the impact of future EU research and innovation (R&I) programmes [42]. A key problem is seen to be that Europe does not capitalise enough on the knowledge it has and produces, either in terms of commercial applications or of solving societal problems. The document does not focus on either the bioeconomy or climate, although it lists societal challenges: “building a digitally-smart, low-carbon, energy-efficient and circular economy that offers rewarding work and brings good quality of life for all in liveable cities and countryside; ensuring a safe climate, building a fair society, keeping our oceans clean and productive” (p. 8).

One of the group’s 12 recommendations is that EU should set research and innovation missions that address global challenges and mobilise researchers, innovators and other stakeholders to realise them. The missions should be easy to communicate and induce action across disciplines, sectors and institutional silos; they could be modelled after the UN SDG; and they should have transformative potential and be measurable.

The group also notes that R&I EU budget should be increased, as well as MS funding and private sector R&I investment. Policies should consistently promote the uptake of innovations, through e.g., public procurement and policy experimentation. Open science and open innovation, as well as collaboration between academia and private sector should be embraced. Stakeholders, end-users and citizens should be involved in defining the missions and measuring their progress.

## **4 Recent European level actors’ communications regarding the bioeconomy**

Analyses and comments on the current Bioeconomy Strategy, as well as calls for its revision and better implementation have recently been made by both EU bodies and various stakeholders. They all agree that the Bioeconomy Strategy is important, but much work is needed before the promise of the bioeconomy can be realised. For example, the European Commission published a review of the EU Bioeconomy Strategy in November 2017. [3]. The review indicates that, even though the Strategy is delivering on key actions in the Action Plan, the policy context in which the bioeconomy operates has changed significantly since 2012 and a revision is needed. Unlike the rest of this report, the following analysis does not focus on carbon issues alone.

1) **Scope of the bioeconomy** is suggested to be both widened and given more detail. The Bioeconomy Strategy and individual MS use different **definitions of the bioeconomy**, and Standing Committee on Agricultural Research Bioeconomy Strategic Working Group (SCAR BSW) suggests clarifying the terms bioeconomy, bio-based economy and green growth/economy [43].

The role of **services** in the bioeconomy should be better understood and advanced [2, 43]. Valorising nature-inspired ideas and insights and applying them to industrial sectors is encouraged [43].

The potential contribution of **cities** to the bioeconomy remains largely unexploited [2, 3]. Strengthening **regional** bioeconomies as well as inter-regional cooperation is emphasised [43, 45].

2) There is a need to clarify the role of the bioeconomy with current international initiatives, particularly the **Paris Agreement** and the **UN Sustainable Development Goals** [2, 3, 43]. The contribution of the bioeconomy in combating and adapting to **climate change** should be clearer and given more priority. A higher than the current price for CO<sub>2</sub> emissions is called for to advance the bioeconomy, as well as an immediate stop to subsidising fossil fuel production [2, 43].

3) **Coherence** between various EU policies is essential. In particular, the Bioeconomy Strategy should be revised to include the Circular Economy approach and create **circular bioeconomy** [3, 43]. Incentives for the bioeconomy could be built into e.g., Ecodesign Directive, EU Ecolabel initiative, waste directives, the Plastic Strategy, and the Fertiliser Regulation [45]. In addition, links to the Energy Union, the CAP, Smart Specialisation strategies, the Common Fisheries Policy (CFP), FP9, and EU Forest Strategy should be developed and clarified [3, 43, 44, 45]. A Commissioner's Bioeconomy cabinet with representation of the services of Commissioners of Agriculture, Research, Regions, Fisheries, Environment, Growth, Energy, Employment and Climate has been suggested to strengthen the coordination [44].

4) **Sustainability of biomass** has been emphasised, particularly in terms of life-cycle impacts and biodiversity [43, 45]. A review coordinated by the European Forest Institute [2] succinctly notes that a circular bioeconomy can help to support biodiversity and climate mitigation, and at the same time biodiversity and climate mitigation are necessary for a successful circular bioeconomy.

5) **Awareness** of the bioeconomy and what it entails is still lacking in the EU. Actions are required towards consumers and professional buyers, such as awareness building and promoting bio-based products' visibility [43, 44, 45]. Seeing the bioeconomy as a key strategy for urban areas, and not only for rural areas, is important, as the circular bioeconomy will not succeed if the urban population does not see its relevance [2].

6) A clear need for dedicated policy tools to support the **development of the markets** of bioeconomy products has been emphasised in many documents [e.g., 3]. It could be promoted through public procurement standards and/or tax regulations favouring products made of renewable raw materials [e.g., 44]. Specific recommendations were published by the Public Procurement Working Group of the European Commission's Expert Group for Bio-based Products. [46]. The recommendations include promotional campaigns targeting specific materials, regions and sectors, the roll-out of standards and labels, benchmarking and goal setting, but also manifesto definition, targeted outreach and general communication, technical support to procurers, as well as intervention on legislation if and where possible. The Expert Group considered the bioeconomy sector to be large and diverse, and acknowledged that it will take time and effort to make a significant impact.

Certification and standardisation of bioeconomy products and processes is called for and methodologies developed by the European Committee for Standardisation CEN are asked to be

implemented [43, 47]. A stable regulatory environment is seen as a requirement for further mobilisation of investments [3].

7) **Funding and investments** are vital for the bioeconomy. Public funding has been a key in implementing the Bioeconomy Strategy so far. It is still considered vital for fundamental research, applied research, near-to-market activities such as demo and pilot plants, and for rolling out solutions to diverse contexts [43, 47]. Private investments in integrated bio-refineries (that convert renewable raw materials, including by-products and waste, into industrial primary and end-products) are considered to require specific support, as they are capital intensive and associated with technological and market risks [3, 45]. Both increased funding and improved coherence of financing mechanisms have been called for and the inclusion of Bio-Based Industries Joint Undertaking (BBI JU) 2.0 in the FP9 has been specifically requested [45].

8) Non-technological **research** is also needed for finding new concepts, novel business models, and understanding consumer needs. **Education** and training is needed for creating understanding of the bioeconomy and for teaching the various skills needed to work within it [43, 44].

9) Better **monitoring and assessment frameworks** are needed to assess the progress, taking into account the ecological, economic and social sustainability and impacts of the bioeconomy [3, 45]. There should be “SMART” (i.e. Specific, Measurable, Attainable, Relevant and Timely) targets and indicators [3]. Transparent and inclusive communication and decision making is required [43].

10) **Sector specific organisations** have raised issues that are of particular importance to them. For example, the European Chemical Industry Council (CEFIC) [47] notes that the European bio-based industries depend on access to renewable raw materials such as sugar, bioethanol or vegetable oils, and asks that users competing for the same materials should be on the same levelled playing field regardless of usage. CEFIC sees the bioeconomy as an opportunity for the industry to diversify its raw material base.

The report coordinated by the European Forest Institute (EFI) [2] covers sectors that are not so commonly associated with the bioeconomy, namely construction, textiles, plastics, and services, emphasizing the role of forests rather than agriculture as a provider of materials and services.

European Bioeconomy Alliance (EUBA) [45], an informal alliance of leading European organisations representing sectors active in the bioeconomy, focuses on the EU Forest Strategy and its multi-annual implementation plan. EUBA considers that they should better promote the bioeconomy and the role of primary producers as the first enablers of the bioeconomy, and asks for the European Commission to present concrete actions on how the EU Forest Strategy will support current and future investments.

## 5 Conclusions

This analysis focussed on carbon and climate issues. Therefore many important aspects of the bioeconomy were excluded, e.g., food security and clean water. Although agriculture and food processing represent a very large share of the bioeconomy in the EU, they have not yet had a very visible role in the bioeconomy efforts from the GHG emission reductions point of view. Therefore they received relatively little attention here. In the future, the role of agriculture in carbon

sequestration is likely to increase, as well as the avoidance of food waste and its use as a feedstock for bio-based products.

The bioeconomy has so far been supported particularly through investments and research, much less through legislation. This may change during a revision process, if the UN SDGs, carbon sequestration, biodiversity, circularity and other new priorities are embraced. The bioeconomy is connected to most SDGs, including Good health and well-being, Clean water and sanitation, Affordable and clean energy, Decent work and economic growth, Industry, innovation and infrastructure, Sustainable cities and communities, Responsible consumption and production, Climate action, Life below water, and Life on land.

## **5.1 Hierarchy and coherence of documents**

EU strategies are often in the form of Commission communications, and as such are not binding, but they guide and direct the EU legislative work. More detailed legislation in the form of Directives or Regulations are binding. The various documents reviewed in the final section are expressions of opinion, and therefore have the least weight. However, they offer a unanimous view that the Bioeconomy Strategy is important, but it needs to be updated and linked better to important policy agreements, other EU strategies, and sectoral legislation. It is not that the Strategy is in contradiction with them; rather the links have not been developed and clarified enough.

Much work is needed on building the coherence, addressing sustainability, and clarifying the roles of consumers and industry. There is a need to develop the circular economy and the bioeconomy in tandem. In addition to investment and research funding, standards, sustainability criteria and other types of regulation will increasingly be needed to promote the bioeconomy. The situation is also constantly evolving, as new issues and topics emerge. For example, so far the plastics regulation has focussed on packaging, but the recent attention on microplastics has increased the importance of substituting fossil materials with bio-based ones in e.g., textiles.

## **5.2 Scope of bioeconomy**

The current Bioeconomy Strategy is limited in scope. Services, ecosystem services, the sustainability of biomass production, and circularity need to be included. There is increasing criticism that the economic dimension of sustainability tends to prevail over social and environmental dimensions [48, 49]. New sectors that have not been widely identified as being relevant to the bioeconomy, such as construction, should also be included in the revision.

A wider group of actors is needed to fulfil the potential of the bioeconomy. These include consumers, cities, regions, the educational and research sectors, service providers, and small-scale biomass producers. The bioeconomy is not only about large-scale industry.

Even the concept of bioeconomy needs clarification. Several definitions exist, and there are parallel concepts, such as bio-based economy and knowledge-based bioeconomy (KBBE). However, all these concepts and their definitions share the idea of a sustainable economy, in which renewable resources are used in production instead of fossil resources [48, 50].

The EU has so far focused in the bioeconomy policy on investments in research, innovations and skills; reinforcement of policy interaction and stakeholder engagement; and enhancement of markets and competitiveness. Different Member States, regions and sectors have their own foci. For example,

Finland has stressed the importance of enhancing markets with e.g., public procurement and tendering, whereas the discussion on the use of cascade principle is weak [48, 50].

The bioeconomy has emerged more strongly in newer documents and the reduction of carbon emissions is a high priority in many present and particularly in future EU policies. However, the exact relation of these two themes is not clear-cut.

### 5.3 Carbon neutrality

The European Union's commitment to climate change mitigation is demonstrated in e.g. the Paris Agreement. Carbon neutrality is a term that has been used to describe a system that has no climate change impacts. However, carbon neutrality is a vague term, and therefore not often used in legislation. It may refer to very significant emission reductions or a situation where the sources and sinks of atmospheric carbon are equal within a production system, country, or the whole globe and within a given time period. EU level documents usually either state quite specific numbers such as emission reduction percentages, or they refer to the climate or need to reduce carbon emissions on a general level.

The bioeconomy can offer solutions to the carbon issue in three ways.

- First, the biomass-producing sectors can upkeep and increase carbon sinks. The new CAP and regulations supporting climate-smart forestry may emphasise this function.
- Second, production of bio-based products having a long lifetime, such as furniture or wooden buildings, may constitute carbon sinks. The cascade principle, waste prevention and sector specific regulations are relevant. Various policy instruments such as economic incentives may be used to encourage increased and prolonged carbon storage in products.
- Third, the bio-based products may substitute non-renewable and fossil-based products, e.g., in chemical industry, packaging, textiles, and energy. Public procurement, various product standards and sectoral policies may be harnessed to increase the markets of these products. It is vital, however, to make sure that the bio-based products really have (significantly) lower GHG emissions over their life-cycle. Sustainability criteria should be drafted for all biomass uses, or carbon impacts could be optimised through comprehensive carbon pricing. It is also vital that the use of bio-based products implements substitution rather than additional production and consumption.

A key problem is that increased use of biomass for production means reduced sinks. There are tradeoffs between the three ways in which the bioeconomy can contribute to the climate challenge. According to global agreements, we need to equalise the sinks and emissions of GHGs, but the richer countries need to be in the forefront of the development. Therefore, it can be argued that the EU should remove more carbon from the atmosphere than it emits. As the EU also imports a great deal of its energy and raw materials, the overall carbon footprint of the Union is larger than that of its own production.

The LULUCF regulation has a no-debit rule and aims for the preservation of the sinks. Increasing the EU sinks is not a target yet.

What are the real tradeoffs of the transition from the fossil economy to the bioeconomy? Could immaterial forms of the bioeconomy replace some of the material forms of consumption? Can

forests, for example, be used for multiple uses while increasing the use of wood? What are the actual climate impacts of various biopaths? These questions remain largely unanswered in the current EU bioeconomy discussion.

#### 5.4 Contradictions and risks

- Specific contradictions were rarely discovered in the materials reviewed here, as they were often on a general level. For example, the European Parliament [19] emphasises that biodiversity protection is an investment into the bioeconomy. The conflicts are likely to arise when more specific cases are considered: e.g., the implementation of biodiversity goals and biomass retrieval on a particular site, or the calculation methods for carbon sequestration.

- Although the carbon neutrality and the bioeconomy are stated EU objectives, subsidies to fossil fuels continue.

- The carbon sequestration in agricultural lands, forests, and different products is not sufficiently addressed.

- The focus on the bioeconomy has been on industrial processes and material production. Services and ecosystem services are not sufficiently supported. All goods and ecosystem services cannot be reached at once, meaning that conflicting objectives will cause problems when more specific pieces of legislation are designed and debated, or when individual sites and their uses are discussed. Specifically, the multifunctionality of forests is not yet fully embraced.

- The competing uses for biomass as well as the competition between sinks and harvests are inbuilt risks in the bioeconomy.

- A potential risk is related to biological products and circularity, and this emerged in the Plastic Strategy Draft: recycling processes may be hampered by biological and biodegrading materials. It is important to build systems that can fully embrace the recycling of materials and the sustainable disposal of biodegradable materials.

- The EU 2030 climate and energy framework instructs that emission reductions should be obtained in the most cost-effective manner possible. However, there are several factors that may undermine cost-efficiency. First, transfers of emission reduction allocations between countries are constrained in many ways. On the other hand, the constraints work as a safeguard against potential accounting loopholes in specific sectors, and they ensure that that all sectors contribute to achieving the targets. Second, credits for net removals by managed forests (exceeding the reference level) are capped, and for some Member States the caps may be binding. This de-incentivises using forests to obtain additional emission reductions. Third, overlapping targets may increase climate policy costs. For example, the renewable energy target partly dictates the means to reduce emissions. Separate policies promoting renewable energy and energy efficiency may also cause disturbances in the ETS.

- Restrictions regarding the use of logging residues from peatlands may be of special interest from the point of view of the Finnish bioeconomy, considering the high number of forests on peat soils.

- The exclusion of feed crops from accepted renewable energy sources may make it impossible to use grass in Finland as a feedstock for biogas. As grass significantly improves the usability of manure in biogas production, it may hinder biogas development. This would have negative results for the nutrient recycling and organic fertiliser initiatives.



- Currently sustainability criteria have been designed for energy use only.
- The importance of biodiversity to the bioeconomy is not sufficiently included in the current Biodiversity Strategy, but in recent reviews it has been brought up. However, it is not very explicitly discussed that protecting biodiversity means that not all areas can be in economic use and that not all methods of usage can be employed.
- Conflicts may arise if users competing for the same raw materials will be on the same playing field regardless of usage. For example, the acquisition of palm oil for biofuels has been considered problematic for climate, food security, and biodiversity reasons.
- Cascade use is considered acceptable in principle, but conflicts may arise if the cascade use is controlled at EU level, as it may turn out very inflexible, leading to possibly unsustainable solutions, and hampering practices which a Member State considers particularly important. In Finland a central issue is the use of wood or wood components as energy. In addition to the many industrial applications, a large number of Finnish households, farms and SMEs use wood products for heating.
- The focus in the bioeconomy discussion is on production, economic growth and employment. Critical views about consumption and material growth are largely absent. All currently used fossil and other non-renewable resources cannot be replaced with biomass. It is doubtful that even all material and energy efficiency measures together could lead to flows that were reduced enough from current (or foreseeable future) flows that they could be based on renewable sources. Limiting consumption and growth is an environmentally sustainable approach, but it may not be politically feasible yet. Emphasising circularity, waste prevention and energy efficiency alongside the bioeconomy is therefore crucial, and discussion on sustainable lifestyles should be more prominent.

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